PROCEEDINGS

OF

THE ROYAL SOCIETY.

1849. No. 75.

Dec. 6, 1849.

GEORGE RENNIE, Esq., Vice-President, in the Chair.

The Chairman announced that the Earl of Rosse had nominated as Vice-Presidents:—

George Rennie, Esq.
Sir B. C. Brodie, Bart.
Sir Roderick I. Murchison.
Professor Owen.
Lieut.-Col. Reid, R.E.
Peter Mark Roget, M.D.

The Right Hon. Thomas Babington Macaulay was admitted into the Society.

Dec. 13, 1849.

In consequence of the funeral of Her late Majesty the Queen Dowager taking place this day, no Meeting of the Society was held.

December 20, 1849.

Dr. ROGET, Vice-President, in the Chair.

A. C. Ramsay, Esq., was admitted into the Society.

The Bakerian Lecture was delivered by Professor Graham, F.R.S., "On the Diffusion of Liquids."

The apparatus used in studying the diffusion of salts and other substances into water was very simple. It consisted of an open phial to contain the solution of the salt to be diffused, which was entirely immersed in a large jar of pure water, so that the solution in the phial communicated freely with the latter. Phials cast in a mould of the capacity of four ounces of water, or more nearly 2000 grains, were generally employed, which were ground down to a uniform height of 3·8 inches. The neck was 0·5 inch in depth, and the

aperture or mouth of the phial 1·25 inch in diameter. The phial was filled up with the solution to be diffused till it reached the point of a pin dipping exactly 0·5 inch into the mouth of the bottle. This being the solution cell or bottle, and the external jar the "water-jar," the pair together form a "diffusion cell." The diffusion was stopped, generally after seven or eight days, by closing the mouth of the phial with a plate of glass, and then raising it out of the water-jar. The quantity of salt which had found its way into the water-jar—the diffusion product as it was called—was then determined by evaporating to dryness.

The characters of liquid diffusion were first examined in detail with reference to common salt.

It was found, first, that with solutions containing 1, 2, 3 and 4 per cent. of salt, the quantities which diffused out of the phials into the water of the jars, and were obtained by evaporating the latter, in a constant period of eight days, were as nearly in proportion to these numbers, as 1, 1·99, 3·01 and 4·00; and that in repetitions of the experiments, the results did not vary more than 1-40th part. The proportion of salt which diffused out in such experiments amounted to about 1-8th of the whole.

Secondly, that the proportion of salt diffused increases with the temperature; an elevation of 80° Fahr. doubling the quantity of chloride of sodium diffused in the same time.

The diffusibility of a variety of substances was next compared, a solution of 20 parts of the substance in 100 water being always used. Some of the results were as follows, the quantities diffused being expressed in grains: chloride of sodium 58·68, sulphate of magnesia 27·42, sulphate of water 69·32, crystallized cane-sugar 26·74, starch-sugar 26·94, gum-arabic 13·24, albumen 3·03. The low diffusibility of albumen is very remarkable, and the value of this property in retaining the serous fluids within the blood-vessels at once suggests itself. It was further observed, that common salt, sugar and urea, added to the albumen under diffusion, diffused away from the latter as readily as from their aqueous solutions. Urea itself is as highly diffusible as chloride of sodium.

In comparing the diffusion of salts dissolved in 10 times their weight of water, it was found that isomorphous compounds generally had an equal diffusibility, chloride of potassium corresponding with chloride of ammonium, nitrate of potash with nitrate of ammonia, and sulphate of magnesia with sulphate of zinc. The most remarkable circumstance is that these pairs are "equi-diffusive," not for chemically equivalent quantities, but for equal weights simply. The acids differed greatly in diffusibility, nitric acid being nearly four times more diffusive than phosphoric acid; but these substances also fell into groups, nitric and hydrochloric acids appearing to be equally diffusive; so also acetic and sulphuric acids. Soluble sub-salts and the ammoniated salts of the metals present a surprisingly low diffusibility; the quantities diffused, under similar circumstances, of the three salts, sulphate of ammonia, sulphate of copper, and the blue ammonio-sulphate of copper being very nearly as 8, 4 and 1.

When two salts are mixed in the solution-cell, they diffuse out into the water atmosphere separately and independently of each other, according to their individual diffusibilities. This is quite analogous to what happens when mixed gases are diffused into air. An important consequence is, that in liquid diffusion we have a new method of separation or analysis for many soluble bodies, quite analogous in principle to the separation of unequally volatile substances in the process of distillation. Thus, it was shown that chlorides diffuse out from sulphates and carbonates, and salts of potash from salts of soda; and that from sea-water the salts of soda diffuse out into pure water faster than the salts of magnesia. The latter circumstance was applied to explain the discordant results which have been obtained by different chemists in the analyses of the water of the Dead Sea, taken near the surface; the different salts diffusing up into the sheet of fresh water, with which the lake is periodically covered, with unequal velocity.

It was further shown that chemical decompositions may be produced by liquid diffusion; the constituents of a double salt of so much stability as common alum being separated, and the sulphate of potash diffusing in the largest proportion. In fact, the diffusive force is one of great energy, and quite as capable of breaking up compounds as the unequal volatility of their constituents. Many empirical operations in the chemical arts, it was said, have their foundation in such decompositions.

Again, one salt, such as nitrate of potash, will diffuse into a solution of another salt, such as nitrate of ammonia, as rapidly as into pure water; the salts appearing mutually diffusible, as gases are known to be.

Lastly, the diffusibilities of the salts into water, like those of the gases into air, appear to be connected by simple numerical relations. These relations are best observed when dilute solutions of the salts are diffused from the solution-cell, such as 4, 2 or even 1 per cent. of salt. The quantities diffused in the same time from 4 per cent. solutions of the three salts, carbonate of potash, sulphate of potash and sulphate of ammonia, were 10·25, 10·57 and 10·51 grains respectively; and a similar approach to equality was observed in the 1, 2, and $6\frac{2}{3}$ per cent. solutions of the same salts. It also held at different temperatures. The acetate of potash appeared to coincide in diffusibility with the same group, and so did the ferrocyanide of potassium. The nitrate of potash, chlorate of potash, nitrate of ammonia, chloride of potassium and chloride of ammonium formed another equi-diffusive group. The *times* in which an equal amount of diffusion took place in these two groups appear to be as 1 for the second to 1·4142 for the first, or as 1 to the square root of 2. Now in gases, *the squares of the times* of equal diffusion are *the densities of the gases*. The relation between the sulphate of potash and nitrate of potash groups would therefore fall, to be referred to the diffusion molecule or diffusion vapour of the first group having a density represented by 2, while that of the second group is represented by 1.

The corresponding salts of soda appeared to fall into a nitrate and

sulphate group also, which have the same relation to each other as the potash salts.

The relation of the salts of potash to those of soda, in times of equal diffusibility, appeared to be as the square root of 2 to the square root of 3; which gives the relation in density of their diffusion molecules, as 2 to 3. Hydrate of potash and sulphate of magnesia were less fully examined, but the first presented sensibly double the diffusibility of sulphate of potash, and four times the diffusibility of the sulphate of magnesia. If these times are all squared, the following remarkable ratios are obtained for the densities of the diffusion molecules of these different salts, each of which is the type of a class of salts, hydrate of potash 1, nitrate of potash 2, sulphate of potash 4, sulphate of magnesia 16, with nitrate of soda 3 and sulphate of soda 6.

In conclusion, it was observed, that it is these diffusion molecules of the salts which are concerned in solubility, and not the Daltonian atoms or equivalents of chemical combination; and the application was indicated of the knowledge of the diffusibilities of different substances to a proper study of endosmose.

January 10, 1850.

GEORGE RENNIE, Esq., Vice-President, Treasurer, in the Chair.

The Right Rev. The Lord Bishop of Manchester was admitted into the Society.

The following papers were read:—

1. "Experiments and Observations upon the Properties of Light." By Lord Brougham, F.R.S. &c.

The author states that the optical inquiries of which he here gives an account were conducted in the first instance under the most favourable circumstances, arising from the climate of Provence, where they were commenced, being peculiarly adapted to such studies: he further states that he subsequently had the great benefit of a most excellent set of instruments made by M. Soleil of Paris; remarking, however, that this delicate apparatus is only required for experiments of a kind to depend upon nice measurements, and that all the principles which he has to note in this paper as the result of his experiments can be made with the most simple apparatus and without any difficulty or expense. His statement of the results of his experiments is thrown into the form of definitions and propositions, for the purpose of making it shorter and more distinct, and of subjecting his doctrines to a fuller scrutiny. He premises that he purposely avoids all arguments and suggestions upon the two rival theories, the Newtonian or Atomic, and the Undulatory.

The following are the author's Definitions and Propositions.

Definitions.

1. *Flexion* is the bending of the rays of light out of their course in passing near bodies.